

SPECIFICATION

Fluorescent Display Device comprising a Pair of Anode Connection Groups

This invention relates to a fluorescent display device comprising a plurality of substantially aligned anode units, each composed of a predetermined number of segmented fluorescent anodes arranged in a preselected configuration. It should be noted here that fluorescent is not much different from phosphorescence and that the word "fluorescent" is used throughout the instant specification to cover the concept of luminescence emitted by a phosphorescent material with a shorter period.

In general, a display device of the type described comprises a plurality of grids opposite the respective anode units and a hot cathode over the grids to provide a visual display of symbols, each of which may be a numeral together with or without a decimal point, a letter of the alphabet, or another symbol. Such a device will herein be called a multidigit fluorescent display device. When the device is driven in a time-division fashion, the grids are driven preferably cyclically. The segmented anodes are selectively driven in one of the anode units that is opposite the grid being energized. There is a tendency in a recent multidigit fluorescent display device to make the grids narrow in the direction of alignment. In a device of the recent type, each digit does not luminesce with a uniform brightness. This results from an undesired influence of adjacent grid or grids as will later be described with reference to some figures of the accompanying drawings.

It is therefore an object of this invention to overcome this problem so that all segmented anodes are capable of substantially uniformly fluorescing even when the grids are narrow in the direction of alignment.

It is another object of this invention to provide a display device of the type described which is capable of being exempted from any adverse influence of an adjacent grid or grids.

The invention is defined in claim 1.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a conventional multidigit fluorescent display device;

Figure 2 is a time chart for describing operation of the display device illustrated in Figure 1;

Figure 3 is a circuit diagram of a multidigit fluorescent display device according to an embodiment of this invention;

Figure 4 is a time chart for describing operation of the display device shown in Figure 3;

Figure 5 is a block diagram of a grid driver used in the display device of Figure 3; and

Figure 6 is a block diagram of anode driver for use in the display device.

Referring to Figure 1, a conventional display device comprises first to seventh substantially aligned grids 11A, 11B, 11C, 11D, 11E,

11F, 11G, each of which corresponds to a digit. The grids 11A—11G are arranged with a spacing therebetween and connected through grid connections to a grid driver (not shown) for driving the grids 11A—11G in a time-division fashion. The grids 11A—11G are in one-to-one correspondence to anode units 11A, 12B, 12C, 12D, 12E, 12F, and 12G. In the example being illustrated, each of the anode units 12A—12G comprises seven luminescent anode segments arranged in a substantially figure-of-eight configuration in order to display a selected one of numerals 0 to 9. First to seventh anode conductors or connections 14a, 14b, 14c, 14d, 14e, 14f, and 14g are connected to the respective segmented luminescent anodes with each of the anode connections 14a—14g connected to a prescribed one of the anode segments in each of the anode units 12A—12G. The respective anode connections 14a—14g are connected to an anode drive (not shown) for selectively driving the anode connections 14a—14g in synchronism with the drive of each of the grids 11A—11G. A hot cathode 15 is supported by supports over all the grids 11A—11G, as symbolized on both sides of this figure. The hot cathode 15 is continuously energized during use of the display device by a cathode driver (not shown) through a pair of cathode connections. The grids, anode units and cathode 15 are enclosed in a vacuum envelope (not shown). The grid, anode, and cathode connections lead out of the envelope.

Referring to Figure 2, the grid driver cyclically produces seven grid energizing pulses GA, GB, BC, GD, GE, GF, and GG in seven time slots T₁, T₂, T₃, T₄, T₅, T₆, and T₇, respectively, within a predetermined time interval, such as one-sixteenth of a second or shorter. The anode driver selectively energizes the anode connections 14a—14g in synchronism with the time slots T₁—T₇. The selective energization in a particular one of the time slots may continue over a plurality of the time intervals. On the other hand, the selective energization may be energization of none of the anode connections particularly in earlier time slot or slots, such as T₁, in at least one time interval. A display of a desired numeral is thereby given by the anode unit opposite the grid being energized.

Thermal electrons emitted from the hot cathode 15 should reach with substantially uniform intensity the selected one or ones of the anode segments of the anode unit opposing the energized grid. This uniform intensity is adversely affected in recent multidigit fluorescent display devices by the adjacent grid or grids which is or are not energized for the time being. The result is that the brightness of a displayed digit becomes weak at the portion adjacent to the next digit or digits.

Referring now to Figure 3, a display device according to an embodiment of the invention comprises first to seventh grids 11A—11G, first to seventh anode units 12A—12G, and a hot cathode 15 as illustrated with reference to Figure

1. The display device further comprises a first group of anode connections 21 for the odd-numbered ones of the anode units, namely the first, third, fifth, and seventh units 12A, 12C, 12E, and 12G, and a second group of anode connections 22 for the even-numbered anode units, namely the second, fourth, and sixth units 12B, 12D, and 12F. In other words, the first group 21 is for every other one of the anode units 12A—12G and the second group, for the remaining anode units. Each of the anode connections 12a—12g of the first group 21 is connected to a prescribed one of the anode segments of each of the odd-numbered anode units 12A, 12C, 12E, and 12G. Each of the anode connections 22a—22g of the second group 22 is connected to a prescribed one of the anode segments of each of the even-numbered anode units 12B, 12D, and 12F.

20 Further referring to Figure 3, the first and seventh grids 11A and 11G will be called end grids for convenience and the remaining grids 12B—12F, intermediate grids. For making the display device display at least one digit, the device further comprises a grid driver 24 connected to the grids 11A—11G through respective grid connections, and an anode energizing circuit 25 connected to the anode connections 21a—21g and 22a—22g. Supplied with an electrical voltage GV, the grid driver 24 energizes all grids 11A—11G, one at a time together with the one adjacent intermediate grid 11B—11F and the two adjacent grids 11A—11G when the first-mentioned one grid is one of the two end grids 11A and 11G and one of the intermediate grids 11B—11F, respectively. The grid driver 24 should energize all grids 11A—11G within the time interval mentioned hereinabove. Each grid is thus energized in at least at one assigned time slot in the time interval. The first-mentioned grid will be referred to as the assigned grid in the following. Supplied with an electrical voltage AV, the anode energizing circuit 25 selectively energizes the anode connections of a specific one of the first and the second groups 21 and 22 without energizing the anode connections of the other of the groups 21 and 22. The specific one group is composed of the anode connections connected to the anode segments of that anode unit which corresponds to the grid the grid driver 24 is energizing as the assigned grid. It is usual that the electrical voltage GV is nearly equal to the voltage AV. The time slots may be defined by a sequence of clock pulses CL generated by a clock generator 26 at a repetition frequency of the order of milliseconds.

Referring to Figure 4, it is preferred that the clock pulses (Figure 3) make the grid driver 24 cyclically specify first to seventh time slots T_1 to T_7 in each time interval, as depicted at the bottom. The time slots T_1 — T_7 are for energizing the first to the seventh grids 11A—11G as the assigned grids, respectively. With reference to the time slots T_1 — T_7 , the grid driver 24 cyclically produces first to seventh

energizing pulses GA, GB, GC, GD, GE, GF, and GG. The first pulse GA has a duration of two time slots, consisting of the first time slot T_1 and the next succeeding time slot T_2 , and is for energizing the first grid 11A as the assigned grid in T_1 and as an adjacent grid (adjacent to the second grid 11B) in T_2 . The second pulse GB has a duration of three time slots, consisting of the second time slot T_2 and the next preceeding and succeeding ones T_1 and T_3 , and is for energizing the second grid 11B as the assigned grid in T_2 and as an adjacent grid (adjacent the first and the third grids 11A and 11C) in T_1 and T_3 . The third to the sixth pulses GC—GF are similar to the second pulse GB and the seventh pulse GG, to the first pulse GA. Timed by the clock pulses CL, the anode energizing circuit 25 selectively energizes the anode connections 21a—21g of the first group 21 simultaneously with energization of each of the odd-numbered grids 11A, 11C, 11E, and 11G when all odd-numbered digits are to be visually simultaneously displayed. When it is desired to display, for example, the least significant digit alone, the anode connections 21a—21g are selectively energized at the seventh time slot T_7 at each time interval. The other anode connections 22a—22g are selectively energized in synchronism with energization of the even-numbered grids 11B, 11D, and 11F. As a result, a selected one of the numerals 0 to 9 is visually displayed by a specific one of the anode units 11A—11G in one of the time slots T_1 — T_7 , at which the grid driver 24 energizes one of the grids 11A—11G as the particular grid, to which the specific anode unit is in one-to-one correspondence.

Turning now to Figure 5, the preferred form of the grid driver 24 cyclically energizes the grids three at each of the time slots (Figure 4). When one of the two end grids is energized as the assigned grid together with the adjacent intermediate grid, the grid driver 24 simultaneously energizes the other end grid. In other words, the grid energizing pulses have a common duration of three time slots. The grid driver 24 comprises a ring counter 33 having a plurality of output leads corresponding to the respective grids. The counter 33 counts the clock pulses CL to cyclically supply grid specifying pulses to the output leads in synchronism with the respective clock pulses. The grid driver further comprises a holding circuit 35 that comprises, in turn, a plurality of holding elements (not shown) for the respective grid specifying pulses. Each holding element may be a one-shot multivibrator responsive to a relevant one of the grid specifying pulses for producing a grid selection pulse that rises at the leading edge of the relevant grid specifying pulse and lasts three time slots. The holding elements therefore cooperate to cyclically produce grid selection pulse sets, each consisting of three grid selection pulses for selecting three of the grids at each time slot. Supplied with the grid selection pulse sets and the electrical voltage GV, a buffer circuit 37 cyclically produces grid

energizing pulses. It is readily understood that the first grid energizing pulse for energizing the first grid 11A as the assigned grid is produced in synchronisms with the clock pulses 2, 9, 16, 23, 30 . . . when the clock pulses are numbered from one from the instant at which the counter 33 is put into operation by closure of a switch 39 (Figure 3).

The form of grid driver described with reference to Figure 5 is suitable for use when the number of anode units is even (since the anode connections to either end unit are not merely different from the anode connections to the adjacent intermediate unit but also the anode connections to the other end unit). If the number is odd, the type of pulse pattern shown in Figure 4 is required and is readily achieved (for the number 7 as the example) by timing GB to GF off T_1 to T_5 respectively with lengthening to three time slots, timing GG off T_6 with lengthening to two time slots only and timing GA not off T_7 but off T_1 with lengthening to two time slots only. The ring counter 33 still has to be a seven stage counter but the seventh output is not used; nothing is timed off T_7 as is apparent from Figure 4.

Referring to Figure 6, the anode driver 25 selectively energizes one of the first and the second groups 21 and 22 of the anode connections at each of the time slots T_1 — T_7 (Figure 4). In the illustrated example, the first-group anode units or the odd-numbered anode units 12A, 12C, 12E, and 12G are energized at the first, third, fifth, and seventh time slots T_1 , T_3 , T_5 , and T_7 , respectively, and the second-group ones or the even-numbered ones 12B, 12D, and 12F, at the second, fourth, and sixth time slots T_2 , T_4 , and T_6 , respectively. The anode driver 25 comprises a memory 42 having a plurality of memory addresses corresponding to the respective anode units 12A—12G. The memory 42 is usually successively supplied with display signals DS, each specifying one of the numerals 0 to 9, from a keyboard or an arithmetic unit for example. Each display signal DS is stored at a relevant one of the memory addresses. The anode driver 25 comprises an address counter 44 responsive to the clock pulses CI for producing an address signal AS that cyclically specifies the memory addresses for the anode units 12A—12G. The address counter 44 is put into operation simultaneously with the counter 33 of the grid driver 24 to make the address signal repeatedly specify, for example, the address for the first anode unit 12A at the instants of the clock pulses 2, 9, 16, 23, 30, . . . , namely, at the first time slots T_1 in the respective time intervals. The stored display signals are read out from the memory 42, one at each time slot, in accordance with the address signal AS. A decoder 45 has a plurality of output leads corresponding to the respective anode segments. Supplied with each read-out display signal, the decoder 45 selectively supplies the output leads with anode energizing pulses for the respective anode segments which are to be energized at the time slot at which the

display signal is read out from the memory 42.

A timing controller 48 is responsive to the clock pulses CL for producing a group selection signal SS for selecting the one group at each of the time slots T_1 — T_7 . The timing controller 48 is put into operation in synchronism with the address counter 44 and cyclically counts the clock pulses CI to a preselected count, such as seven, to make the group selection signal SS alternately specify the first and the second groups 21 and 22 in each time interval. For example, the group selection signals SS cyclically specifies the first, second, and other anode units 11A, 11B, . . . in synchronism with the clock pulses 2, 3, . . . , 9, 10, . . . 16, 17, . . . , 23, 24, . . . , 30, 31, and so on. An electrical power AV and the anode energizing pulses are supplied to a selector 49 connected to the anode connections of the first and the second groups 21 and 22.

Responsive to the group selection signal SS, the selector 49 supplies successive sets of the anode energizing pulses alternately to the connections of the first and second groups 21 and 22 in each time interval.

Among possible modifications, the invention is equally well applicable to a display device having more or less anode units than shown. The grids may be arcuately aligned. There may be a plurality of hot cathodes. The switch 39 (Figure 3) is referred to merely as an example of means for synchronizing the anode driver 25 with the grid driver 24.

Claims

1. A fluorescent display device comprising two end grids, a plurality of intermediate grids between and in substantial alignment with the end grids, a plurality of anode units in one-to-one correspondence with the grids, a hot cathode over the anode units with all the end and intermediate grids interposed therebetween, each of the anode units being composed of a predetermined number of fluorescent anode segments arranged in a preselected configuration, a first group of anode connections for first ones of the anode units, each of the connections being connected to a prescribed one of the anode segments of each of the first anode units, and a second group of anode connections for the remaining second anode units, each of the second-group anode connections being connected to a prescribed one of the anode segments of each of the second anode units, the first anode units being every other one of all the anode units.
2. A fluorescent display device as claimed in Claim 1, further comprising grid energizing means responsive to an electrical voltage supplied thereto for energizing the grids within a predetermined time interval composed of a plurality of time slots assigned to the grids respectively, the assigned grid and the or both immediately adjacent grids being energized in each time slot, and an anode energizing circuit responsive to an electrical voltage supplied thereto for selectively energizing, within each



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energizing pulses. It is readily understood that the first grid energizing pulse for energizing the first grid 11A as the assigned grid is produced in synchronisms with the clock pulses 2, 9, 16, 23, 30... when the clock pulses are numbered from one from the instant at which the counter 33 is put into operation by closure of a switch 39 (Figure 3).

The form of grid driver described with reference to Figure 5 is suitable for use when the number of anode units is even (since the anode connections to either end unit are not merely different from the anode connections to the adjacent intermediate unit but also the anode connections to the other end unit). If the number is odd, the type of pulse pattern shown in Figure 4 is required and is readily achieved (for the number 7 as the example) by timing GB to GF off T_1 to T_5 respectively with lengthening to three time slots, timing GG off T_6 with lengthening to two time slots only and timing GA not off T_7 but off T_1 with lengthening to two time slots only. The ring counter 33 still has to be a seven stage counter but the seventh output is not used; nothing is timed off T_7 , as is apparent from Figure 4.

Referring to Figure 6, the anode driver 25 selectively energizes one of the first and the second groups 21 and 22 of the anode connections at each of the time slots T_1 — T_7 (Figure 4). In the illustrated example, the first-group anode units or the odd-numbered anode units 12A, 12C, 12E, and 12G are energized at the first, third, fifth, and seventh time slots T_1 , T_3 , T_5 , and T_7 , respectively, and the second-group ones or the even-numbered ones 12B, 12D, and 12F, at the second, fourth, and sixth time slots T_2 , T_4 , and T_6 , respectively. The anode driver 25 comprises a memory 42 having a plurality of memory addresses corresponding to the respective anode units 12A—12G. The memory 42 is usually successively supplied with display signals DS, each specifying one of the numerals 0 to 9, from a keyboard or an arithmetic unit for example. Each display signal DS is stored at a relevant one of the memory addresses. The anode driver 25 comprises an address counter 44 responsive to the clock pulses CI for producing an address signal AS that cyclically specifies the memory addresses for the anode units 12A—12G. The address counter 44 is put into operation simultaneously with the counter 33 of the grid driver 24 to make the address signal repeatedly specify, for example, the address for the first anode unit 12A at the instants of the clock pulses 2, 9, 16, 23, 30, ..., namely, at the first time slots T_1 in the respective time intervals. The stored display signals are read out from the memory 42, one at each time slot, in accordance with the address signal AS. A decoder 45 has a plurality of output leads corresponding to the respective anode segments. Supplied with each read-out display signal, the decoder 45 selectively supplies the output leads with anode energizing pulses for the respective anode segments which are to be energized at the time slot at which the

display signal is read out from the memory 42.

A timing controller 48 is responsive to the clock pulses CL for producing a group selection signal SS for selecting the one group at each of the time slots T_1 — T_7 . The timing controller 48 is put into operation in synchronism with the address counter 44 and cyclically counts the clock pulses CI to a preselected count, such as seven, to make the group selection signal SS alternately specify the first and the second groups 21 and 22 in each time interval. For example, the group selection signals SS cyclically specifies the first, second, and other anode units 11A, 11B, ... in synchronism with the clock pulses 2, 3, ..., 9, 10, ..., 16, 17, ..., 23, 24, ..., 30, 31, and so on. An electrical power AV and the anode energizing pulses are supplied to a selector 49 connected to the anode connections of the first and the second groups 21 and 22. Responsive to the group selection signal SS, the selector 49 supplies successive sets of the anode energizing pulses alternately to the connections of the first and second groups 21 and 22 in each time interval.

Among possible modifications, the invention is equally well applicable to a display device having more or less anode units than shown. The grids may be arcuately aligned. There may be a plurality of hot cathodes. The switch 39 (Figure 3) is referred to merely as an example of means for synchronizing the anode driver 25 with the grid driver 24.

Claims

1. A fluorescent display device comprising two end grids, a plurality of intermediate grids between and in substantial alignment with the end grids, a plurality of anode units in one-to-one correspondence with the grids, a hot cathode over the anode units with all the end and intermediate grids interposed therebetween, each of the anode units being composed of a predetermined number of fluorescent anode segments arranged in a preselected configuration, a first group of anode connections for first ones of the anode units, each of the connections being connected to a prescribed one of the anode segments of each of the first anode units, and a second group of anode connections for the remaining second anode units, each of the second-group anode connections being connected to a prescribed one of the anode segments of each of the second anode units, the first anode units being every other one of all the anode units.

2. A fluorescent display device as claimed in Claim 1, further comprising grid energizing means responsive to an electrical voltage supplied thereto for energizing the grids within a predetermined time interval composed of a plurality of time slots assigned to the grids respectively, the assigned grid and the or both immediately adjacent grids being energized in each time slot, and an anode energizing circuit responsive to an electrical voltage supplied thereto for selectively energizing, within each

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time slot, the anode connections of one of the first and second groups without energizing the anode connections of the other of the groups, the said one group comprising the anode connections
5 connected to the anode segments of that one of the anode units which corresponds to the assigned grid.
3. A fluorescent display device as claimed in Claim 2, further comprising a clock generator for
10 generating a sequence of clock pulses defining the time slots, wherein the grid energizing means comprises means responsive to the clock pulses for successively producing grid selection pulse sets, each consisting of three grid selection
15 pulses, for cyclically selecting the grids, three at each time slot, and means responsive to each of the grid selection pulse sets for supplying the electrical voltage to the three grids selected thereby, the three grids being the assigned grid
20 and both adjacent grids when the assigned grid is one of the intermediate grids, and being the adjacent intermediate grid and the other of the end grids when the assigned grid is either of the

end grids.
25 4. A fluorescent display device as claimed in Claim 3, wherein the grid selection pulse set producing means comprises means for counting the clock pulses to successively produce grid specifying pulses cyclically specifying all of the
30 grids, one at each time slot, and means for lengthening each of the grid specifying pulses to extend over three time slots to produce each of the grid selection pulse sets.
5. A fluorescent display device as claimed in Claim 3 or 4, wherein the anode energizing circuit
35 comprises a timing controller responsive to the clock pulses for producing a group selection signal for alternately selecting the first and second groups of anode connections in the
40 successive time slots in each time interval, means for selectively producing anode energizing pulses for the respective anode segments in the selected group, and means responsive to the electrical power, said group selection signal, and the anode
45 energizing pulses for selectively energizing the anode connections of the selected group.